

LECTURE NOTES

ON

ENGINEERING CHEMISTRY

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CHAPTER -1

ATOMIC STRUCTURE

DISCOVERY OF ELECTRONS:

It is discovered by Thomson' Cathode ray experiment. Charge and mass of electron are 1.602×10^{-19} coulomb and 9.11×10^{-31} kg.

Charge on one mole of electrons = 96500 coulombs = 1F

DISCOVERY OF PROTONS:

It is discovered by E.Goldstein. The charge on proton is $+1.620 \times 10^{-19}$ coulombs and mass of proton is 1.672×10^{-27} k.g Charge on 1 mole of protons = 96500 coulombs.

DISCOVERY OF NEUTRON : (Chadwick)

Chadwick bombarded some lighter elements like Be, B with fast moving α – particles He detected some neutral particles having mass slightly more than the mass of proton.

Due to the electrical neutrality of the particles these are called neutrons. This is another fundamental particle present in every atom of the element except protium. i.e ${}_1\text{H}^1$

mass of neutron = 1.675×10^{-24} gm
 $= 1.675 \times 10^{-27}$ kg

Atomic number (Z)

It is defined as the no. of unit (+) ve charges or the protons present in the nucleus of an atom.

Atomic number (z) = Number of protons
 = Number of electrons

Ex. : Atomic number of calcium means an atom of calcium consists of 20 protons, 20 neutrons and 20 electrons.

Mass Number (A) :

Mass number is the number of particle that present in the neucleus. i.e mass number (A) = no. of protons + no. of neutrons i.e $A = Z + n$

e.g – Mass number of ‘Na’ is 23 and ‘Ca’ is 40.

Atomic Structure :

Atomic structure means the arrangement of sub-atomic particles (proton, electron, neutron) in an atom. These arrangement are explained through different models.

a) Thomson’s Model:

According to this model an atom consists of a (+) vely charged sphere within which the (-) vely charged electrons are distributed in arbitrary position in order to neutralize the charge.

Limitation of Thomson’s Model :

It fails to explain the experimental facts observed latter. (e.g – Spectral analysis)

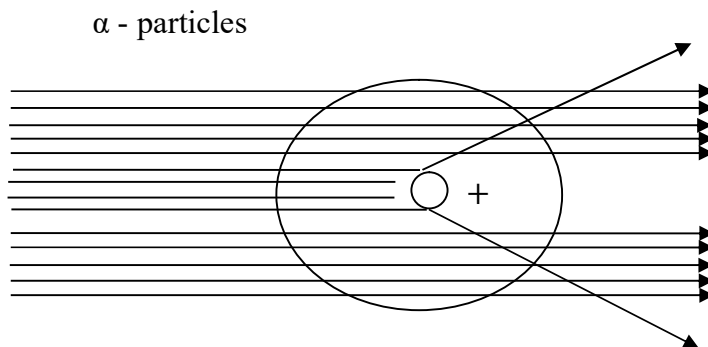
Rutherford’s Atomic Model:

The atom consists of two sub atomic particles :

- i) Negatively charged particles (electrons)
- ii) Positively charged particles (protons)

Rutherford’s Experiment :

Rutherford bombarded α – particles emitted from a radioactive substance on a very thin gold foil. The scattered rays are observed through semicircular screen coated with ZnS salt.



Observation:

- i) A large fraction of α – particles went undeflected i.e they passed straight through the thin foil.

- ii) Few α – particles deflected with certain angles.
- iii) A very few (0.1%) particles even retrace their own path that means reflected through almost 180° .

Inference:

- i) Since most of the α – particles passed straight through the gold foil without any deflection, a large portion of an atom must be empty.
- ii) Since few α – particles deflected from their normal straight path, there must be some heavy and positively charged body called as nucleus.

Conclusion :

- i) An atom consists of two parts.
 - a) Nuclear part b) Extra nuclear part
- ii) Nucleus is a very small but heavy (+)vely charged body, where whole mass of atom is concentrated. This is the central part of the atom.
- iii) The extra nuclear part contains the revolving (-)vely charged electron. Those electrons are compared with the planets in the solar system. Thus this atomic model is called planetary model. Electrons are called planetary electrons.

Drawbacks of Rutherford's Atomic model:

- i) It fails to explain the stability of the atom. Because as per Maxwell electron on subsequent revolution may lose energy and may fall in to the nucleus.
- ii) It fails to explain the hydrogen spectra.
- iii) The model is silent about the definite energy and velocity possessed by the revolving electron.

Bohr's atomic model:

To overcome the limitations of Rutherford Model and to explain the spectral lines, Bohr postulated another model basing on plank's quantum theory.

Postulates of Bohr's atomic Model:

- i) Electrons revolve around the nucleus, the massive central part in certain definite permitted circular path known as stationary states or orbits or shells.
- ii) These shells possess fixed value of energy hence these are called energy levels or stationary states.

iii) The energy of an electron in a particular orbit is given by –

$$E_n = -\frac{313.6}{n^2} \text{ KCal / mol for hydrogen atom}$$

Where the ‘n’ values are 1, 2, 3.... indicating K, L, M, N Shells. Thus the energy in the first shell i.e K-shell = - 313.6 kCal / mole

$$\text{Energy of the 2}^{\text{nd}} \text{ shell (L-shell)} = \frac{-313.6}{2^2} = -78.4 \text{ kcal/ mole}$$

Different energy levels aren't equally spaced. It goes on decreasing with the increase in the value of ‘n’

iv) Angular momentum (mvr) of an electron in an orbit is equal to whole number multiple of $h/2\pi$.

$$mvr = n \frac{h}{2\pi}$$

Where $n = 1, 2, 3, 4, \dots$,

h is plank's constant

m = mass of the electron

v = Velocity of the electron

r = radius of the orbits.

v) When electron jumps from higher orbit to lower orbit the energy is released. But when electron jumps from lower orbit to higher orbit energy is absorbed.

$$\text{The energy absorbed and emitted} = h\nu = E_{\text{higher}} - E_{\text{lower}}$$

Where ν is the frequency of energy emitted / absorbed

Thus emission or absorption takes place only when electron jumps from one orbit to another.

vi) When the electrons in an atom are in their lowest energy state they keep on revolving in their respective orbits without losing energy. This state of atom is called normal or ground state. After gaining energy electron jumps from lower state to higher state. This state of atom is called excited state which is the unstable state.

Drawbacks of Bohr's atomic Model:

- i) It fails to explain the line spectra of multi electron system like Be
- ii) It fails to explain the 3- dimensional model of atom.
- iii) According to Bohr's model the position and velocity of fast moving small electron can be calculated. But this is against Heisenberg's uncertainty principle.
- iv) It fails to explain the cause of chemical combination and the shapes of the molecules arising out of it.
- v) It doesn't explain the splitting of spectral lines on the application of magnetic field.

BOHR – BURY MODEL:

Postulates are –

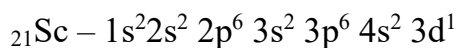
1. The maximum number of electrons present in an orbit is equal to $2n^2$ where 'n' is the no. of the orbit as follows –

Number of shell (n)	Number of electrons($2n^2$)	
K – shell	1	$2 \times 1 = 2$
L – shell	2	$2 \times 2^2 = 8$
M – shell	3	$2 \times 3^2 = 18$
N – shell	4	$2 \times 4^2 = 32$

2. The outer most orbit of an element cannot contain more than 8 electrons and the orbit immediately before it can not contain more than 18 electrons .

3. It isn't always necessary to complete an orbit before the next orbit starts filling.

Ex- The electronic configuration of Sc is



Here '4s' sub shell is filled before '3d' sub shell

Hund's rule of maximum multiplicity:

Definition : Pairing of electrons doesn't take place in the degenerate orbitals of p, d and f sub-shell until each orbital contains a single electron with same spin.

The above is due to the reason that electrons being identical in charge repel each other when present in the same orbital. This repulsion can be minimized if two electrons move as far apart as possible by occupying different degenerate orbital.

Ex Let us consider 3 electrons present in P subshell.

The correct way of arrangement of electron in orbitals is $P_x^1 P_y^1 P_z^1$ (not $P_x^2 P_y^1 P_z^0$)

Aufbau's Principle:

Aufbau's is a German word with meaning building up. Thus, this principle helps in filling of the orbital with electrons. According to this principle the electrons are filled in different sub shell in order of increasing energy i.e the electron first occupies the lowest energy orbital and then enters to next higher energy orbital. The energy of different orbital's can be known from the $(n + l)$ rule.

Rule – 1 :

Lower is the $(n+l)$ value lower is the energy.

For '1s' $n=1$, $l=0$, $n+l=1$

For '2s' $n=2$, $l=0$, $n+l=2$

Thus, $E_{1s} < E_{2s}$

Rule -2 :

For sub-shells with identical $(n+l)$ value, lower is the energy for lower 'n' values.

For 4s, $n+l = 4 + 0 = 4$

$$3p, \quad n+1 = 3+1=4$$

Thus, $E_{3p} < E_{4s}$. as 'n' value for 3p is less.

Subshell	Energy(n+l)	Subshell	Energy(n+l)
1s	1+0= 1	4s	4+0=4
2s	2+0=2	4p	4+1=5
2p	2+1=3	4d	4+2=6
3s	3+0=3	5s	5+0=5
3p	3+1=4	5p	5+1=6
3d	3+2=5		so on

Thus increasing order of energy is.....

$$1s < 2s < 2p < 3s < 3p < 4s < 3d \quad \text{so on}$$

Electroni configuration of some element

${}_1\text{H}$	1s1
${}_2\text{He}$	1s2
${}_3\text{Li}$	1s2 2s1
${}_4\text{Be}$	1s2 2s2
${}_5\text{B}$	1s2 2s2 2p1
${}_6\text{C}$	1s2 2s2 2p2
${}_7\text{N}$	1s2 2s2 2p3 (2px1 2py1 2pz1)
${}_8\text{O}$	1s2 2s2 2p4 (2px2 2py1 2pz1)
${}_9\text{F}$	1s2 2s2 2p5 (2px2 2py2 2pz1)
${}_{10}\text{Ne}$	1s2 2s2 2p6 (2px2 2py2 2pz2)

CHEMICAL BONDING

Bonding is the combination of atoms to form a molecule. Atoms combine to have stable electron configuration or to satisfy octet rule.

Definition: A chemical bond is defined as a force of attraction which holds together the constituent atoms in a molecule.

Types of chemical bond :

There are 3 main types of chemical bonds. Such as :

- a) Electrovalent / Ionic bond
- b) Covalent bond
- c) Dative bond or co-ordinate bond

Ionic bond / Electrovalent bond :

Features:

- a) Here the bond is formed between two dissimilar atoms (A & B).
- b) Atom 'A' has tendency to lose one or more electron by occupying stable electronic configuration and form (+) vely charged ion (cation)

Eg – $\text{Na(g)} - e^- = \text{Na}^+(\text{g})$ (Iso electronic with Ne)

- c) Another atom 'B' has tendency to accept one or more electron occupying stable electronic configuration and formed (-) vely charged ion (anion).

$\text{Cl(g)} + e^- = \text{Cl}^-(\text{g})$ (Iso electronic with Ar)

- d) These ions are held by strong electrostatic force of attraction as a result the potential energy is decreased.
- e) The electrovalence of an atom is the no. of electron that it can gain or lose to have stable electronic configuration.

Factors affecting electrovalent bond formation:

- a) Ionization Energy (I.E) :

Lower is the I.E easier is the formation of cation and stronger is the ionic bond.

b) Electron affinity :

Higher is the electron affinity easier is the formation of anion and stronger is the ionic bond.

c) Force of attraction :

Stronger is the force of attraction between the oppositely charged ions stronger is the ionic bond.

Explanation of the formation of Ionic bond.

Example of the formation of CaCl_2

The electronic configuration of Ca and Cl are given below, such as -



The electrostatic force of attraction between Calcium and chloride ions result in the formation of CaCl_2 .

Ex – KCl, KBr, KI, CaF_2 , CaBr_2

Covalent Bond :

Features-

- (i) A covalent bond is formed between two similar or dissimilar atoms ($\text{A} - \text{A}$ or A-B)
e.g – ($\text{H} - \text{H}$, H-Cl)
- (ii) Here both the atoms are short of electrons to have stable configuration.
- (iii) Both the atoms share mutually such that each atom occupies stable configuration.
- (iv) According to covalent bond molecules have two types of electrons-----
 - a) Bond pair of electrons / shared pair of electrons i.e those take part in mutual sharing .
 - b) Unshared pair of electron/ lone pair of electron.

These pair of electrons doesn't take part in sharing but satisfies octet.

Ex- In Oxygen molecule each oxygen atom has two electrons as bond pair, where as other 4 electrons present as 2 lone pairs

Fig---

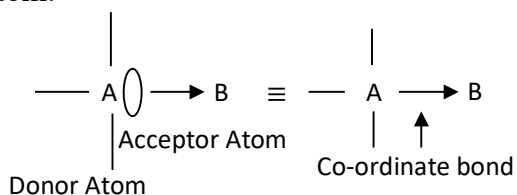


Dative bond/ Co-ordinate bond :

Features:

- i) Like covalent bond this bond is formed between two similar or dissimilar atoms.
- ii) Here one of the atom is short of electrons to have duplet or octet configuration and such atoms are called acceptor atom.
- iii) Another atom is having an excess pair of electrons (lone pair) and termed as donor atom.
- iv) The donor atom partially shared a pair of electron with the acceptor atom such that both the atoms satisfy stable electronic configuration (duplet / octet)
- i) The bond is represented by an arrow heading towards the acceptor atom from the donor atom.

Fig

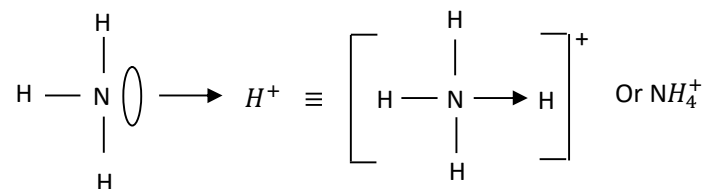


- vi) Thus the chemical bond formed by partial donation and partial sharing of lone pair of electron between two atoms or ions is called a co-ordinate / dative bond.

Ex – NH_4^+ , H_3O^+

Formation of ammonium ion-

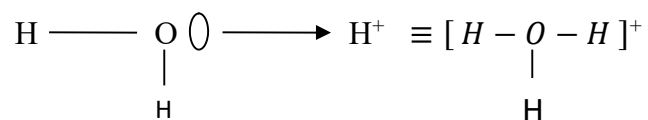
Fig



Here one atom can share the electron pair but both will satisfy the stable configuration . ‘N’ satisfies octet and ‘H’ satisfies the duplet state.

Formation of hydronium ion -----

Figs



Here Oxygen satisfies Octet and ‘H’ satisfies duplet.

ACID AND BASE THEORY

1.2 Arrhenius theory of Acid Base:

According to this Acids are the substances that can provide H^+ ion in aqueous medium

ex : HCl , HNO_3 , CH_3COOH etc

Bases are those that can provide OH^- ion in aqueous medium.

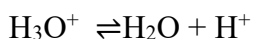
Ex: $NaOH$, $Ca(OH)_2$, $Al(OH)_3$

Bronsted – Lowry Theory :

According to this theory acids are those substances capable of donating proton or acids are proton donors.

Base are those species capable of accepting proton or bases are proton acceptor.

Example of Acid ;

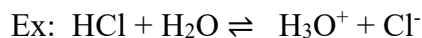


Example of Bases :

All anions are Bronsted Lowry base.

Ex: Cl^- , SO_4^{2-} , PO_4^{3-} etc.

By proton transfer conjugate pair of acids and bases are formed.



(acid) (base) (acid) (Base)

Hence Cl^- is a conjugate base of acid HCl

H_3O^+ is a conjugate acid of base H_2O .

Thus, acid – H^+ = conjugate base,

Base + H^+ = conjugate acid



(Conjugate base) (conjugate acid)

Lewis Theory :

According to Lewis theory

- An acid is a substance which can accept a pair of electrons from any other substance i.e electrons acceptors are acids.
- A base is a substance which can donate a pair of electrons to any other substance. i.e electron pair donors are bases.

Examples of acids :

- All cations are Lewis acids. Such as Na^+ , K^+ , Ca^{2+} , Cu^{2+} , Al^{3+} , Fe^{3+} etc.
- Neutral molecules containing electron deficient atoms are Lewis acids
Eg – BF_3 , AlCl_3 , FeCl_2 , ZnCl_2 etc

Examples of Bases :

- All anions are Lewis bases – F^- , Cl^- , Br^- , OH^- , CN^- , NO_2^- , O^{2-} , S^{2-}

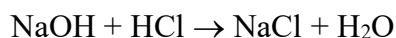
Salt :

It is formed by complete neutralisation of aqueous solution of strong acid with an aqueous solution of a strong base.

Neutralization of Acid and Base :

Salts are formed out of acid base reactions by replacement of H^+ ion of an acid by any metal ion or other cation. Thus, these are electrovalent compound of which the cations come from a base (basic radical) and anions come from an acid (acid radical)

Ex:



Here, Na^+ is a part of base NaOH and Cl^- is a part of acid HCl.

Classification of Salt : (On action of water)

- Salts of strong acid and strong base :

NaCl / KNO_3 , the solution is neutral.

- Salts of strong acid and weak base

Ex – NH_4Cl - the solution is acidic



- Salt of strong base and weak acid :

Ex- CH_3COONa the solution is alkaline

$$pH > 7$$

d) Salt of weak acid and weak base :

Eg – CH_3COONH_4

These type of salts are either acidic or alkaline depending on the degree of dissociation of acid and base / relative proportion of H^+ and OH^- ions in solution. In case, the acid is relatively stronger compared to the base, the solution will be acidic. Also a relatively stronger base in the neutralization reaction with a weak acid forms a basic solution.

SOLUTIONS

Equivalent weight of acid, base & salt :

Equivalent weight of Acid = Mol mass/ Basicity

Where Basicity = No of H^+ ion replaceable

Ex- Equivalent mass of $HCl = \frac{36.5}{1}$

$$H_2SO_4 = \frac{98}{2} = 49$$

Equivalent weight of base = $\frac{Mol.mass}{Acidity}$

Acidity = No. of OH^- ion replaced.

Eg. – Equivalent mass of $NaOH = 40$

$$\text{Equivalent mass of } Ca(OH)_2 = \frac{74}{2} = 37$$

$$\text{Equivalent mass of } Al(OH)_3 = \frac{Mol.mass}{3} = \frac{78}{3} = 26$$

Equivalent weight of salt = $\frac{Mol.mass}{Total\ charge\ on\ cation/ anion}$

Eg : Equivalent mass of $Na_2SO_4 = \frac{Mol.mass}{2}$

$$\text{Equivalent mass of } (Al)_2(SO_4)_3 = \frac{Mol.mass}{6}$$

Standard Solution :

The solution whose strength is known is called standard solution.

Normal Solution ;

when one gram equivalent of a Solute is dissolved in one liter solution, then it is termed as Normal Solution

Ex- Equivalent weight of NaOH =40 .

When 40 gm of NaOH dissolved in 1 lit solution, normal solution of NaOH is formed.

Molar solution:

When one mole of a solute is dissolved in one litre solution, it is called a molar solution.

Ex –Molecular mass of $\text{NaCO}_2 = 106$

When 106gm of Na_2CO_3 is dissolved in 1 lit solution, one molar solution of Na_2CO_3 is formed.

Molal Solution :

When 1 mole of solute present in 1000gm of a solvent, it is called 1 molal solution.

Ex: 106 gm of Na_2CO_3 in 1000gm of solvent.

Normality – (N) :

It is defined as the no. of gram equivalent of the solute present per litre of the solution at a given temperature.

$$N = \frac{\text{no. of gram equivalents}}{\text{Vol}^m \text{ of solution}}$$

$$N = \frac{w}{E} \times \frac{1000}{V}$$

$$\frac{w}{E} = \text{No. of gm equivalent.}$$

W = wt. of the solute

E= Equivalent wt. of the solute.

If 1 gm equivalent present in 1 litre solution i.e called 1 N solution.

Molarity (M) It is the no. of moles that present per liter of solution at a given temperature.

$$\text{Molarity}(M) = \frac{w}{M} \times \frac{1000}{V}$$

Where w = wt of the solute

M= molecular mass of solute

v= volume of solution

Molality(m) :

It is the no. of mole that present per kg of solvent.

$$\text{Molality (m)} = \frac{\omega}{M} \times \frac{1000}{\omega'}$$

Where $\rightarrow \omega$ = wt. of the solute ω' = wt. of the solvent.

M = Mol. Mass of the solute

1Molal solution means 1 mole of solute present in 1 kg of water.

pH :

pH of the solution is the power of hydrogen ion concentration in the solution .

Mathematically : It is expressed as (-) ve logarithm of molar concentration of hydrogen ion

i.e $\text{pH} = -\log [\text{H}^+]$

or
$$\text{pH} = -\log \left[\frac{1}{[\text{H}^+]} \right]$$

so, pH decreases with rise in concentration of hydrogen ion.

pH scale ranges from 0-14 with a midpoint at '7'

Importance of PH value in industries

1. Water for domestic use :

The pH values of the public water supplied should preferably be between 7.2 to 8.0. If $\text{pH} < 7.2$ then corrosion may occurs and $\text{pH} > 7$ indicate certain physiological effects.

2. Water treatment:

pH control is required for treatment of sewage waste by coagulation process, other wise the added coagulants are not fully hydrolysed and they are in effective to bring about sedimentation of fine suspended and colloidal impurities. Optimum pH value varies from 4.2 to 7.6 , when alum is used as cation co-agulant.

3. In Sewage Treatment:

The pH value from 7.3 to 7.56 is required to decide which particular organism will bring about the decomposition most satisfactorily.

4. **Corrosion** : In $\text{pH} < 5$, the corrosion of iron structure in oxygen free water is slow, but the rate of corrosion is very high in presence of oxygen at pH 4 to 5 and 10 to 12.

5. **In chemical industry :**

pH adjustment is required to have a proper control over the reaction.

- S6. **Sugar Industry :**

The pH of the juice is maintained to 7. If it is acidic (i.e $\text{pH} < 7$) the sucrose in the juice is hydrolyzed to glucose and fructose mixture. But if the juice becomes alkaline ($\text{pH} > 7$) undesirable acids and coloured substances are produced.

7. **In electroplating :**

To have adherent, smooth and shining deposits, the pH of the electroplating bath is to be carefully controlled.

ELECTROCHEMISTRY.

Electrolyte:

The substances which conduct electricity in their fused state or in aqueous solution are called electrolytes.

Ex- HCl, H₂SO₄, NaOH, KOH, NaCl etc.

Types of electrolyte-

Electrolyte is of two types.

- 1) Strong electrolyte
- 2) Weak electrolyte.

1) Strong electrolyte:

The substance which ionizes completely in solution is known as strong electrolyte.

It produces large no of ions in solution.

Ex- Strong acids- HCl, HNO₃, H₂SO₄ etc.

Strong base- NaOH, KOH etc.

Salts- NaCl, NaNO₃, KCl etc.



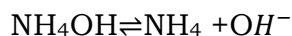
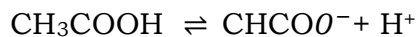
2) Weak electrolyte:

The substance which ionizes slightly in solution is known as weak electrolyte.

It produces less no of ions in solution.

Ex- Weak acid-CH₃COOH, HCOOH, H₂CO₃ etc.

Weak base- NH₄OH, Ca(OH)₂ etc.



Electrolysis: The process of chemical decomposition of an electrolyte in solution or in the fused state by the passage of electric current is known as electrolysis.

Illustration: (1) Electrolysis of fused NaCl {using platinum electrode}

When NaCl is heated to high temperature, it melts and ionises as follows.



Reactions takes place at different electrode.

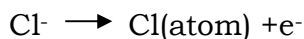
AT Cathode:-

Na^+ ions move towards cathode, lose their charge by gain of electron and change into neutral atoms.

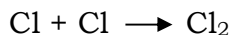


AT Anode:-

Cl^- ion move towards anode, lose its charge by loss of electron and change into neutral atoms.



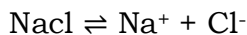
The Cl atom being unstable combine with another atom to form stable chlorine molecule.



(2) Electrolysis of aqueous NaCl.

[Using pt electrode]

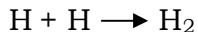
When NaCl is dissolved in water, it ionises as follows:



a) Reaction at cathode:

Both Na^+ and H^+ ions towards Cathode. However only H^+ ions are discharged more readily then Na^+

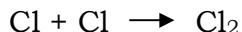
Thus H^+ ions gain electron and form hydrogen molecule.



b) Reaction at anode:

Both Cl^- and OH^- ions move towards anode. However only Cl^- ions are discharged more readily than OH^- ions.

Thus Cl^- ions lose electron and form chlorine molecule.



Electrolytic cell:

Electrolytic cell is a device in which electrical energy is converted into chemical energy.

Chemical reaction in an electrolytic cell is non-spontaneous and proceeds only when electrical energy is supplied.

The two electrodes are placed in a solution or molten electrolyte in the same container. In the cell anode is a positive and Cathode is a negative electrode. The electron flows from cathode to anode.

FARADAY'S LAWS OF ELECTROLYSIS.

Faraday's First law:

Statement:- The mass of the substance liberated at the electrode as a result of electrolysis is directly proportional to the quantity of electricity passed through the electrolyte.

Explanation: Let W is the mass of substance liberated.

Q= quantity of electricity passed through the electrolyte.

Then according to Faraday's 1st Law-

$$W \propto Q \text{ -----(1)}$$

It is known that

$$Q = I.t$$

Where I= Current in amp.

t=time in sec.

so equation (1) can be written as $W \propto I.t$

$$\text{or } W = Z.I.t \dots (2)$$

where Z is a Constant as is Called Electrochemical Equivalent (ECE)

If $I = 1 \text{ amp.}$

and $t = 1 \text{ sec.}$

Then $W = Z$

Thus Electrochemical equivalent of a substance is defined as the mass of substance liberated when 1amp of current is passed through the electrolyte for 1sec.

Or

ECE is the mass of the substance liberated by the passage of 1coulumb of electricity.

It is found that, When one Faraday (=96500c) of electricity passed, the substance deposited =1gm eqv.

∴ When 1c of electricity is passed, the substance deposited

$$= \frac{1\text{gm equivalent}}{96500} = \frac{E}{96500} = ECE(Z)$$

Putting this value of 'z' in equation(2)

We get $W=Z.I.t$

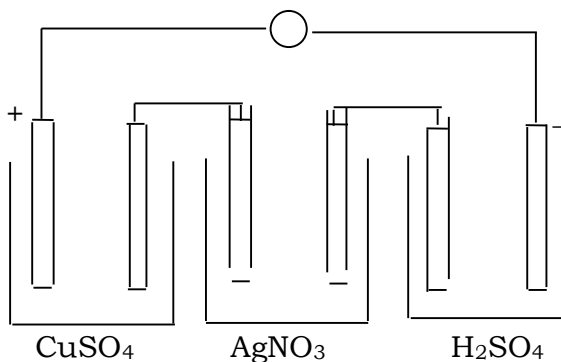
$$W = \frac{E}{96500} \times I \cdot X \cdot t$$

Faraday's second law-

Statement:- When same quantity of electricity is passed through different electrolytic solutions, the weights of different substances produced at the electrode are proportional to their equivalent weights.

Explanation:-

Let us consider three electrolytic cell containing AgNO_3 , CuSO_4 and H_2SO_4 solution respectively and connected in series.



Let, W_{Cu} = Weight of Cu deposited

W_{Ag} = Weight of Ag deposited

W_H = Weight of Hydrogen liberated

E_{Cu} = Equivalent weight of Cu

E_{Ag} = Equivalent weight of Ag

E_H = Equivalent weight of hydrogen.

Then according to 2nd law.

$$W \propto E$$

So $W_{Ag} \propto E_{Ag}$ and $W_{Cu} \propto E_{Cu}$

$$\text{Thus } \frac{W_{Ag}}{W_{Cu}} = \frac{E_{Ag}}{E_{Cu}}$$

$$\text{Similarly, } \frac{W_H}{W_{Cu}} = \frac{E_H}{E_{Cu}}$$

INDUSTRIAL APPLICATION OF ELECTROLYSIS.

ELECTROPLATING: It is carried out for different purposes as follows.

(a) Decoration- Superior metals like gold, silver etc are deposited over baser metals to enhance their beauty.

(b) Protection- from rusting of metals.

(c) Repairing- broken parts of machinery.

CHROMIUM PLATING:

ELECTROLYTIC BATH:

It consist of (i) chromic acid ($HCrO_4$). (ii) Chromic sulphate.

The temperature of the bath is 40-45°C, The anode consist of lead and 8% antimony.

APPLICATION- Chromium plating produces a hard, corrosion resistant film with attractive appearance and brightness. It has low co-efficient of friction.

It is used in automobile industry, dies, tools and sanitary fittings etc.

ZINC PLATING-

For Zinc plating acid and alkaline solutions are used for deposition.

ELECTROLYTIC BATH-

A) Acidic solution-It consist of a solution of

i) Zinc sulphate

- ii) Sodium Chloride
- iii) Aluminium sulphate
- iv) Boric acid
- v) Dextrin in 1000ml of water.

B) Alkaline Solution- It consists of

- i) Zinc oxide
- ii) Sodium cyanide
- iii) Sodium Carbonate in 1000ml of water.

The temperature of solution is kept at 30-40°C

APPLICATION:

Zinc plating is carried out on iron to protect it from rusting.

.

ELECTROCHEMICAL CELLS.

Electrochemical cell is a cell which produce electricity as a result of chemical reaction.

Cells are of two types-(1):Primary Cells (2):Secondary Cells.

1)Primary Cells- These are such cells which do not have indefinite life and become dead over a time when the reaction stops.

Such cells cannot be recharged or used again.

Ex:- Dry Cell, Mercury Cell etc.

Dry Cell- It consist of following parts

a) Anode(Zinc Container)—Zinc Container act as anode and is covered with card board to protect it from the atmosphere.

b)Cathod--- Graphite rod surrounded by a mixture of powdered carbon and manganese dioxide (MnO_2) act as Cathode.

c)Electrolyte—A paste of NH_4Cl and ZnCl_2 fitted between anode and Cathode act as electrolyte.

Mercury cell

It consist of

- 1) Anode-Zinc-mercury amalgam (Zn/Hg) act as anode.
- 2) Cathode- Mercury (II) Oxide (HgO) and Carbon act as Cathode.
- 3) Electrolyte- A paste of ZnO-KOH act as electrolyte.

Secondary cells:

These are such cells which can be recharged by passing direct current through them and can be used again and again.

Ex- Lead-Storage cell nickel Cadmium storage cell etc.

Lead storage cell:

Storage cell can operate both as voltaic cell and an electrolytic cell.

It consists of

- 1)Anode- A lead grid packed with spongy lead act as anode.
- 2)Cathode- A grid of lead packed with lead dioxide (PbO_2) act as Cathode.
- 3)Electrolyte- An aqueous solution of H_2SO_4 (38% by mass) act as electrolyte.

Nickel-cadmium storage cell:

It consist of

- 1) Anode-Cadmium electrode act as anode.
- 2) Cathode- A metal grid containing nickel (iv) oxide (NiO_2) act as cathode.
- 3) Electrolyte- KOH solution acts as electrolyte.

CORROSION

Definition- corrosion is a process involving the conversion of a metal into an undesirable compound on exposure to atmospheric condition ie moisture and oxygen.

Types of Corrosion-

Corrosion is of following types,

1- Atmospheric corrosion

2- Waterline Corrosion

1- Atmospheric Corrosion- When a metal is exposed to the atmosphere an oxide film is formed on the surface due to interact with atmospheric air.

As long this protective oxide film is maintained on the entire metal surface, further attack of corrosion does not occur. But however if this oxide film breaks down due to electrochemical action on the metal surface due to the presence of moisture or any electrolyte, corrosion proceeds further.

Ex-Tarnishing of silver, development of green coating on copper and bronze, rusting of iron. In case of iron, corrosion is known as rusting,

2-Waterline corrosion:

This type of corrosion takes place due to difference in oxygen concentration.

When water is stored in a steel tank, it is noticed that considerable corrosion takes place along a line just below the level of the water meniscus.

The area above the water line is called Cathodic part because in this area the oxygen concentration is more. The area just below the water line is anodic part because here the concentration of oxygen is less. These two electrode cause corrosion to take place.

Ex-Corrosion in ships, water, tanks etc.

METHODS TO PROTECT METAL FROM CORROSION:

Due to corrosion metallic products are destroyed. There are some methods to protect the metal from corrosion.

1)Alloying of metals-Alloys are mixture of two or more metals. Alloys resist corrosion in the ways.

a) Homogeneity-Alloying of metals increases homogeneity which in turn decreases the rate of corrosion. Noble metals or metals which are not active to the environment are considered for alloying. Uniform alloy can attain maximum corrosion resistance.

Ex-The loss of iron due to rusting is minimized by alloying it with chromium.

b) Oxide film-In certain cases, the oxide film formed on the surface of the metal increases the corrosion resistance.

Ex-Durion is a silica-iron alloy-It is highly resistant to acids since silicon oxide film is formed on its surface.

2)Cathodic protection:

This method involves the protection of the metallic object buried in the ground or immersed in water from corrosion. The objects can contain anodic and cathodic areas. But corrosion occurs only at the anodic area. If the whole surface area of metal is turned into cathode, only then corrosion can be prevented.-

a)Sacrificial anode protection:

In this method less electropositive metal is protected with the help of more electropositive metal. Less electropositive metal act as cathode and more electropositive metal act as anode.

Ex- Zinc is used to protect iron from rusting. Zinc being more electropositive metal than iron, it losses electrons in preference to iron and is consumed in the course of time. Thus iron is prevented from rusting. The process of covering iron with zinc is called galvanization.

3)Impressed voltage method

This method is employed to protect structure immersed in electrolyte.

An impressed current is applied in the opposite direction to the corrosion current which converts the corroding metal from anode to cathode. Thus structure is protected.

METALLURGY

Minerals:

A few metals or their compounds are found in the earth crust is called mineral.

Example:-Zincite, NaCl, Na₂SO₄, NaNO₃ etc.

Ores:

The minerals from which the metals can be extracted conveniently and profitably are called ores.

Ore contains high percentage of metal. Thus, all the ores are minerals but all minerals are not ores.ex- Fe₂O₃ (Haematite) is a minerals of iron.

Metal	Chief Ore
Iron	Haematite, Fe ₂ O ₃ Magnetite Fe ₃ O ₄
Aluminium	Bauxite (Al ₂ O ₃ , 2H ₂ O), Corundum(Al ₂ O ₃)
Copper	Cuprite (Cu ₂ O)
	Melachite (CuCO ₃ , Cu(OH) ₂)
	Copper pyrite (CuFeS ₂)
Zinc	Zincblend (ZnS)
	Zincite (ZnO)
Lead	Galena (PbS)
	Cerrusite (PbCO ₃)
Mercury	Cinnabar (HgS)
Chromium	Chromite (FeCr ₂ O ₄)

Q) All ores are minerals but all minerals are not ores. Justify the statement.

A: All ores are minerals but all minerals are not ores because hematite and iron pyrite are minerals of iron but iron pyrite contain lower percentage of iron & is associated with impurities like sulphur, phosphorous etc., is not used for the extraction of iron. Thus iron pyrite is not an ore of iron.

Similarly the important minerals of copper are copper glance, copper pyrite, and cuprite. But out of these copper can be conveniently extracted from copper pyrite. Thus, the ore of copper is copper pyrite.

Flux:

It is the substance which is added at the time of smelting to remove the basic or acidic impurities as fusible slag.

Thus,



Types of flux:

Flux is of two types

i) Acidic flux

ii) Basic flux

i) Acidic flux-

If the impurity is basic the flux used is acidic.

Ex... SiO_2 , P_2O_5 etc

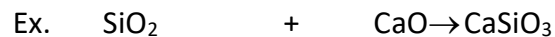


(Basic impurity) (acidic flux) Iron silicate (Slag)

ii) Basic flux

If the impurity is acidic the flux used is basic.

Ex. MgO , CaO etc



(Acidic impurity) (Basic flux) (Slag)

Slag:

Slag is formed when flux react with gangue, which is an easily fusible material but not soluble in molten metal.

Extraction of metal from ore:

The process of extraction of metal from ores profitably and conveniently is known as metallurgy. Different steps involve in metallurgy are:

- i) Crushing and Grinding of ore
- ii) Concentration of the ore

- iii) Oxidation
- iv) Reduction
- v) Refining

i) Crushing and Grinding of Ore:

- a) By jaw crusher and
- b) By the stamp mill

ii) Concentration of the ore:

Increase in the percentage of ore by removing the impurities (gangue) is called concentration. Different methods are used for different ores. These methods are:

a) Gravity Separation Method:

In this case Wilfley table containing certain horizontal grooves are used. The table is kept slightly inclined position and powdered ore is placed over it. Then water is spread over it. The table is provided with rocking movement so that lighter impurities are washed away with water while heavier ore particles get deposited in grooves and are finally carried out into the main canal.

b) Froth floatation method :

By this process sulphide ores are concentrated. Here the ore is preferentially wetted by oil and the gangue particles by water. The powdered ore oil (pine oil) and water are agitated with blowing air. The sulfide ores along with the foam floats over the surface of water and passes over to the 2nd tank living behind the impurities at the bottom of the first tank.

c) Magnetic Separation:

If the ore or impurities are magnetic separation can be done by this method. An electro magnet is rotated by means of a moving belt the powdered ore is dropped, Hooper over the belt on movement the magnetic ore move towards the pulley whereas the non-magnetic impurities separates and moves away from the pulley.

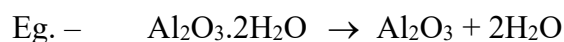
iii) Oxidation:

The ore is oxidized by following method:

- a) **Calcinations:** It is a process of heating the concentrated ore in absence of air or in the limited supply of air at a temperature just below its melting point.

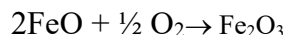
As a result-----

- i) Moisture from ore is removed

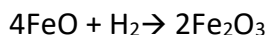
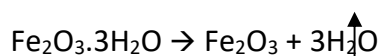


Bauxite Alumina

- ii) It removes volatile impurities like As and Sb etc.
- iii) The carbonates are converted into their oxides. Eg. $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$
- iv) Some oxides oxidized to their higher oxidation state.



- v) Mass becomes porous

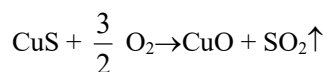
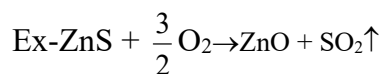


- b) **Roasting**: It is a process of heating the concentrated ore strongly in a controlled supply of oxygen in a reverberator furnace to get metal oxide.

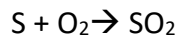
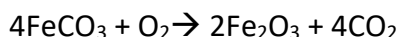
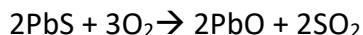
This process is generally used to convert sulphide ore into metallic oxides. The main functions of roasting are as follows:

As a result –

- It removes moisture in the form of steam.
- It removes volatile impurities like As, Sb, etc.
- The carbonates are converted into their oxides.
- Ex. $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$
- The oxidisable substances like ferrous are oxidized into their higher oxidation state (ferric)
- Ores are converted into their oxides.



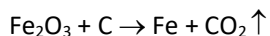
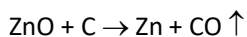
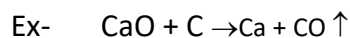
- It makes the ore porous



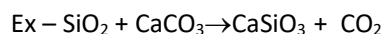
iv) Smelting:

The process of conversion of metal oxide (in a process of roasting or calcination) metal oxide into metal or reduction of metal oxide.

The roasted ore is mixed with suitable quantity of the coke or charcoal which acts as reducing agent the mixture is heated to a high temperature above its melting point.

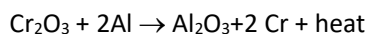


Impurity + Flux \rightarrow Fusible slag



These are the examples of carbon reduction process.

Except this the other reducing agents used are Aluminum, hydrogen, water gas ($\text{CO} + \text{H}_2$) etc.



(Aluminothermi process)

Coke: It is used as reducing agent.

v) Refining / Purification :

The metals obtained during the above metallurgical operation may contain impurities. The impurities usually consists of following

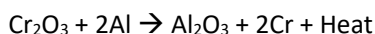
- i) Other metals obtained by simultaneous reduction of respective oxides present in the ore as impurity.
- ii) Non-metals like silicon or phosphorous formed by reduction in the furnace.
- iii) Un reduced oxides or sulfides of metal.
- iv) Some impurities like residual flux, slag etc, introduced during treatment of the furnace.

Different methods are employed for the refining of the metals-----

i) Distillation ii) Liquation iii) Electro-refining iv) Zone-refining etc

Q) Write notes on aluminothermy process.

A: Certain metal oxides such as Cr_2O_3 , Mn_3O_4 etc., cannot be reduced by carbon or carbon monoxide. In such cases, Aluminium is used as a reducing agent because it is more electropositive than Chromium & Manganese. The process is called Aluminothermy. In this process, calculated quantity of aluminium powder is mixed with the metal oxide and a layer of "Barium peroxide is mixed with the metal oxide and a layer of magnesium wire (a few cms long) is inserted in the mixture & ignited. The reaction starts and a lot of heat is produced when aluminium and oxygen react to form aluminium oxide (Al_2O_3)



ALLOYS

ALLOY:

Alloy is a homogeneous solid formed by melting together two or more metals or metal & non-metals (carbon, phosphorous, silicon etc.).

Types of Alloys-

- a) Ferro alloys: The alloy which contain iron as one of the constituent metal.
Eg: Steel, Ferrochrome.
- b) Non- ferro alloys: The alloy which do not contain iron as one of the constituent metal.
Eg: Brass, Bronze etc.

Composition and uses of-

NAME	COMPOSITION	USES
BRASS	Cu=60-80%, Zn=40-20%	Radiator, condenser tube & cartridges
BRONZE	Cu=75-90%, Sn=25-10%	Coins, Statues
DURALUMIN	Al=95%, Cu=4%, Mn=0.5%, Mg=0.5%	For making air ships
ALNICO	Fe=50%, Ni=21%, Al=20%, Co=1%	For making permanent magnet

AMALGAMS:

It is an alloy in which mercury is one of its constituent metal.

Eg: a) Sodium amalgam (Na-Hg): It is used as a good reducing agent.

b) Copper amalgam (Cu-Hg): It is used for filling dental cavities.

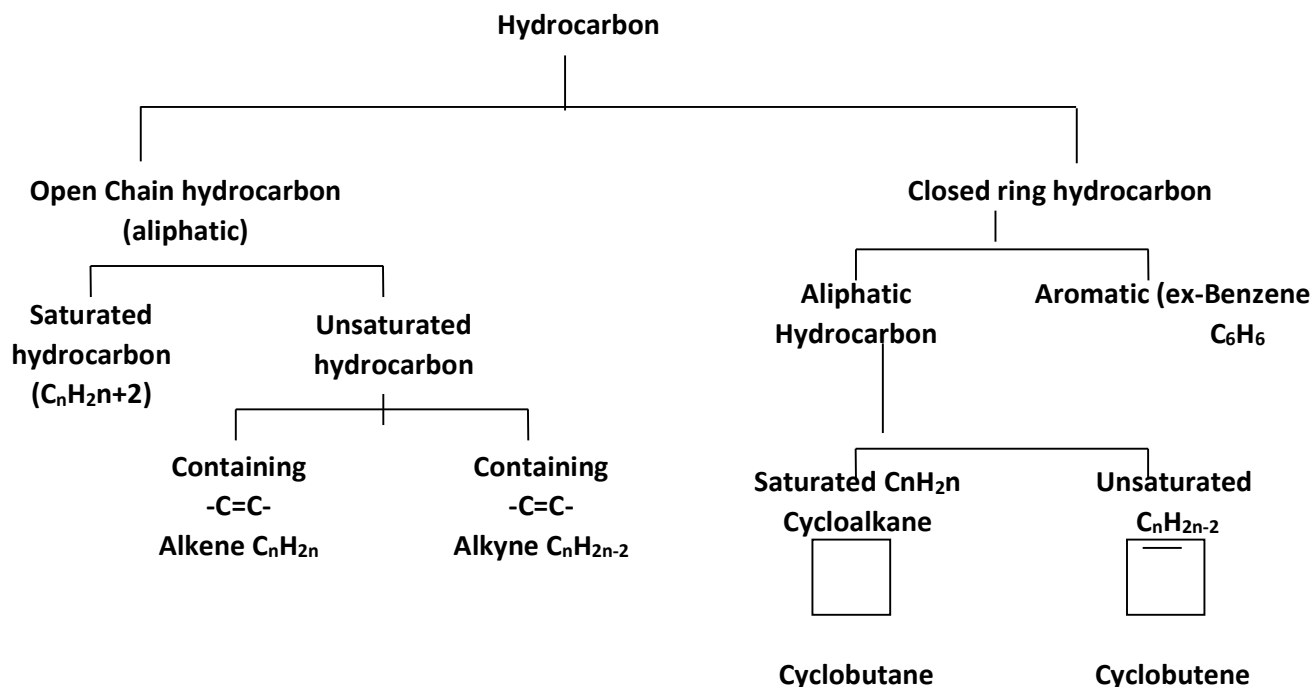
c) Tin amalgam (Sn-Hg): It is used for silvering cheap mirrors.

Note: Iron doesn't form amalgam with mercury.

HYDROCARBONS

Hydrocarbon: Hydrocarbons are compounds of carbon and hydrogen.

Classification:



ALIPHATIC HYDROCARBON:

The open chain hydrocarbons are called aliphatic hydrocarbon. It is of two types-

- Saturated hydrocarbon
- Unsaturated hydrocarbon

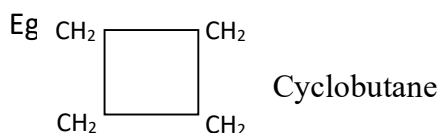
Q) Difference between saturated and unsaturated hydrocarbon.

SATURATED HYDRO CARBON	UNSATURATED HYDRO CARBON
The hydro carbon having carbon-carbon single bond in the chain.	The hydro carbon having carbon-carbon double/triple bond in the chain.
Eg: Alkane(CH ₄ , C ₂ H ₆ etc)	Eg: Alkene(C ₂ H ₄ etc) and Alkyne(C ₂ H ₂ etc)

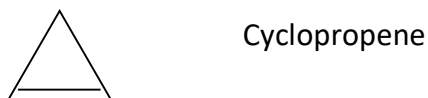
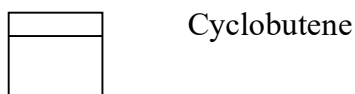
ALICYCLIC HYDROCARBON:

The cyclic or ring compound having carbon atom at each corner of ring is called alicyclic hydrocarbon. It is of two types-

a) Saturated alicyclic hydrocarbon



b) Unsaturated alicyclic hydrocarbon



Q) Define aromatic hydrocarbon. Justify that benzene is an aromatic hydrocarbon.

A: The cyclic hydrocarbon compound which obey Huckel's rule that means it contain $(4n + 2)\pi$ electron. When $n=0,1,2,\dots$ (n =no. of rings)

Benzene is having 1 ring that means $n=1$, hence

$$(4n + 2)\pi = (4 \times 1 + 2)\pi = 6\pi \text{ Electron}$$

According to Huckel's rule benzene is having 6π electron. Hence it is



Benzene is having alternate double bond. Three double bond implies 6π electron in benzene. Hence benzene is an aromatic hydrocarbon which Huckel's rule.

IUPAC Nomenclature :

Alkanes having suffix -ane with general formula C_nH_{2n+2} .

C_1 methane CH_4 C_6 Hexane C_6H_{14}

C_2 Ethane C_2H_6 C_7 Heptane C_7H_{16}

C ₃ Propane	C ₃ H ₈	C ₈	Octane	C ₈ H ₁₈
C ₄ Butane	C ₄ H ₁₀	C ₉	Nonane	C ₉ H ₂₀
C ₅ Pentane	C ₅ H ₁₂	C ₁₀	Decane	C ₁₀ H ₂₂

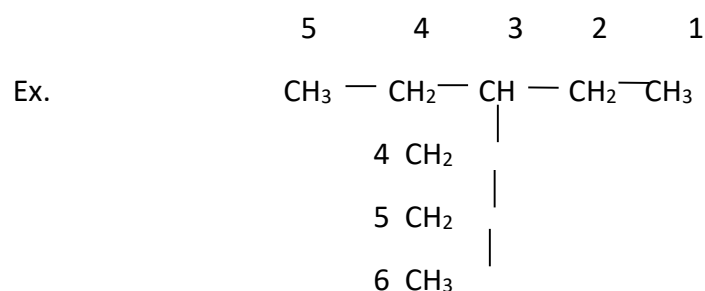
The radical of alkane is called alkyl-- ,With formula C_nH_{2n+1} – represented as R – and suffix –yl.

Ex – CH₃ – methyl, C₂H₅ – Ethyl

Rules of Nomenclature of alkane:

<a>Longest Chain Rule:-

Count the chain in such a manner that it contains large no. of carbon atom in the chain.

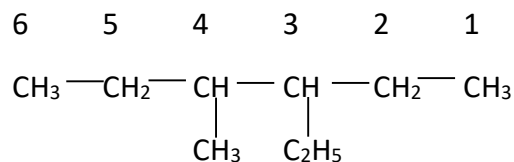


3- Ethyl hexane.

Not 3- Propyl Pentane.

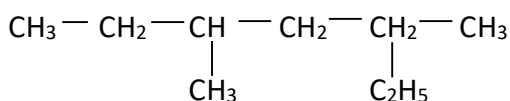
Naming the different substituents of equivalent positions:-

If two different substituents are present at equivalent positions from the two ends of the parent chain, then the numbering of the chain is done in such a way that the substituents which comes first in the alphabetical order gets the lower number.ex:-



3- Ethyl – 4-methyl hexane





2-Ethyl-5-methyl hexane

<c>Rule for branched substituent in the chain (lowest sum rule) :-

If the chain contains more than one branch then count the chain in such a direction that sum of their position will be lowest one.

Ex:- 2, 2, 4 – Trimethyl pentane.

Alkene :

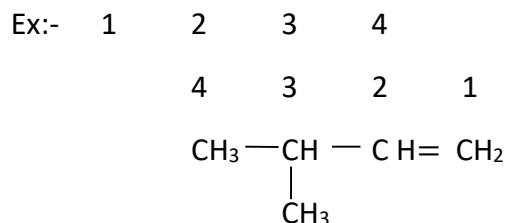
Alkene with general formula C_nH_{2n} and suffix – ene, n = no. of carbon atom and 2,3,4.....'n' can't be one.

n=2, C_2H_4 = Ethene

n=3, C_3H_6 = Propene

n= 4, C_4H_8 = Butene

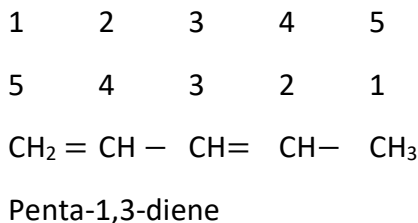
Rule – 1 : The chain contains = bond and branch. '=' bond is prefer to branch.



3-Methyl but-1-ene

Rule -2 :

Chain containing more than one '=' bond is termed as diene, triene for 2, 3 '=' bonds. The position of the '=' bond follows lowest, sum rule.



Alkyne:

Rule – 1:

General formula C_nH_{2n-2} and suffix -yne, where $n = 2, 3, 4, 5$ etc.

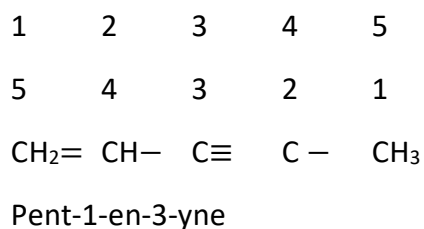
If	$n = 2$	Ethyne
	$n = 3$	Propyne
	$n = 4$	Butyne

Rule – 2 :Chain containing double & triple bond

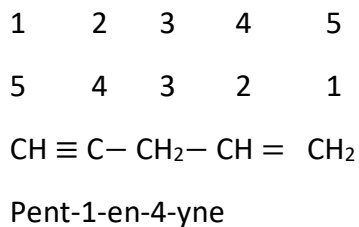
Lowest sum Rule:

- a) Sum of the position of the double and triple bond must be lowest.

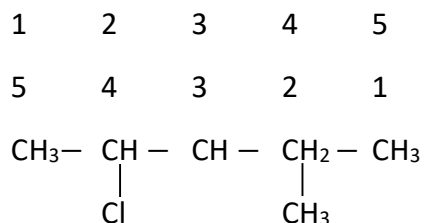
Naming first 'en' then 'yne' is written.eg –



- b) In case of identical sum double bond is preferred to triple bond

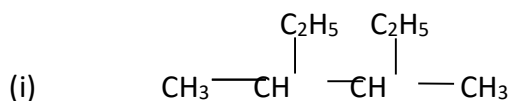
**Alkyl Halide:**

Halogen is treated as a prefix and the prefixes are to be arranged alphabetically obeying lowest sum rule.

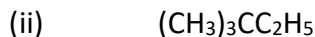


Ex :- 2-Chloro-4-methyl Pentane

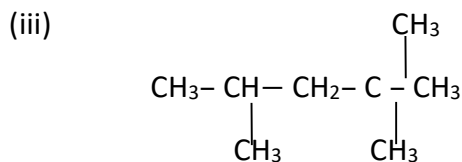
Practice:-



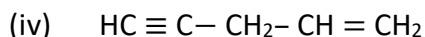
2-Ethyl – 3 -Methyl pentane.



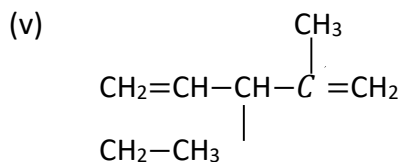
2,2- Dimethyl butane.



2,2,4 – Trimethyl pentane.



Pent – 1 - en - 4 –yne



3- Ethyl – 2- Methyl penta – 1,4-diene

ALCOHOL (ROH):

It is having suffix- 'ol'.

GENERAL NAME	GENERAL FORMULA	EXAMPLE
Alkanol	$\text{C}_n\text{H}_{2n+1}\text{OH} / \text{C}_n\text{H}_{2n+2}\text{O}$	If n=1, $\text{CH}_3\text{-OH}$ (methanol) n=2, $\text{CH}_3\text{-CH}_2\text{-OH}$ (ethanol) n=3, $\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-OH}$ (propan-1-ol)
Alkenol	$\text{C}_n\text{H}_{2n}\text{O}$	If n=2, $\text{CH}_2=\text{CH-OH}$ (ethenol) n=3, $\text{CH}_2=\text{CH-CH}_2\text{-OH}$ (prop-2-en-1-ol) $\text{CH}_2=\text{CH-CH}_3$ (prop-1-en-2-ol) OH

Alkyno	$C_nH_{2n-2}O$	If $n=2$, $HC \equiv C-OH$ (ethynol) $n=3$, $CH \equiv C_2-CH_2-OH$ (prop-2-yn-1-ol)
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Uses of hydrocarbon in daily life:

BENZENE is used-

- in dry cleaning.
- as a motor fuel when mixed with petrol.
- as a solvent.
- as an insecticide (as gammaxene is prepared from it).
- as a starting material for the preparation of dyes, drugs, plastics, insecticides.

Toluene is used-

- as a substitute of petrol.
- in the manufacture of certain dyes and drugs
- an industrial solvent and in dry cleaning.

Phenol is used-

- as an antiseptic in soaps, lotions and ointments.
- as a preservative for ink.
- in the preparation of fungicides & bactericides.

Naphthalene is used-

- for manufacture of dyes, explosives and synthetic resins.
- for commercial production of phthalic anhydride, α -naphthol, β -naphthol
- for increasing the illuminating power of coal gas.

Anthracene is used-

- for manufacture of anthraquinone
- for making (alizarine)
- in smoke screens.

Benzoic acid is used-

- in the treatment of skin diseases like eczema
- as medicine especially as urinary antiseptic in the form of its salt.
- in the preparation of aniline blue

WATER TREATMENT

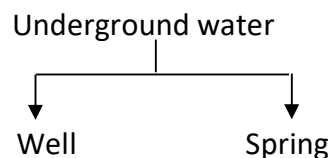
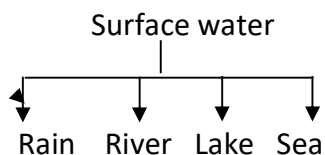
Sources of water

Water



Engg.Chemistry

Mr.Rakesh K. Beura



Types of water

Water is of two types :

- a) Soft water b) Hard water

a) **Soft water** : The water which produces enough foam or lathers with soap solution is called soft water. Eg – rain water, demineralised water, distilled water.

b) **Hard Water** : The water which doesn't produce much foam or lathers with soap solution is called hard water.

Eg. Sea water, River water, Pond water

Hardness of water :

The characteristic of water which prevents the formation of foam with soap solution is due to the presence of certain chemical like $\text{Ca}(\text{HCO}_3)_2$, $\text{Mg}(\text{HCO}_3)_2$, CaCl_2 , MgCl_2 , FeSO_4 etc is hard water. The unit of hardness is parts per million (PPM).

Hardness is two types such as :

- i) Temporary or carbonate hardness
- ii) Permanent / non –carbonate hardness

i) Temporary hardness :

The temporary hardness of water arises due to the presence of bicarbonates of Ca & Mg i.e $\text{Ca}(\text{HCO}_3)_2$, $\text{Mg}(\text{HCO}_3)_2$. Temporary hardness is also called carbonate hardness.

Temporary hardness can be removed by boiling.

ii) Permanent Hardness :

The permanent hardness of water arises due to the presence of CaCl_2 , MgCl_2 , FeSO_4 , FeCl_2 , etc in it. Where calcium hardness results from calcium compounds and magnesium hardness from magnesium compounds. When the dissolved calcium and magnesium salts are measured by treating with standard soap solution. The hardness is usually termed as soap hardness. Permanent hardness can't be removed by boiling.

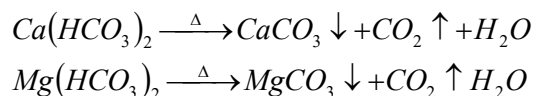
Softening :

The process of decreasing the hardness of water is called softening. It involves decreasing the concentration of calcium and magnesium salts in water. The term softening is applied to the process whereby we remove or reduce the hardness of water, irrespective of whether it is temporary or permanent hardness.

The various methods are used to softening of hard water as follows.

a) Removal of Temporary Hardness of Water:

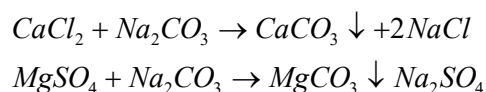
The temporary hardness of water can easily be removed just by boiling the water. Water on boiling, the soluble $\text{Ca}(\text{HCO}_3)_2$ and $\text{Mg}(\text{HCO}_3)_2$ becomes insoluble which can be filtered off to get soft water.



Removal of permanent hardness however requires chemical treatment.

Removal of hardness by lime soda process :

Permanent hard water is treated with calculated quantity of sodium carbonate solution, calcium and magnesium salts present in water get precipitated as insoluble carbonates.



Lime soda process:-

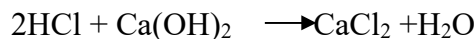
In this process water is treated with calculated quantity of lime $\text{Ca}(\text{OH})_2$ and soda.

(Na_2CO_3). The contents are mixed well and the precipitate of CaCO_3 and $\text{Mg}(\text{OH})_2$ formed are removed. Lime soda process is carried in two ways:-

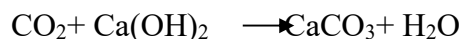
- (i) Cold lime soda process- It causes only partial softening of hard water.
- (ii) Hot lime soda process- in this process, water is fully softened and water obtained can be safely used in boilers.

1. Function of lime (i.e $\text{Ca}(\text{OH})_2$)

- (i) It neutralises acids in water.



- (ii) It removes dissolved CO_2



- (iii) It removes bicarbonates of calcium and Magnesium i.e. it removes temporary hardness.

Softening of Hard water by Exchange of ions :

This is the most modern method of softening water. In this method, the ions responsible for the hardness are exchanged with other ions which don't make water hard. The hardness of water can be removed by two types of ion exchanges :

- 1) Organic ion exchangers called ion exchange resin.
- 2) Inorganic ion exchangers such as permutit, calgon etc.

Organic Ion-exchangers (Ion Exchange resins).

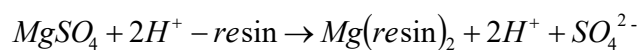
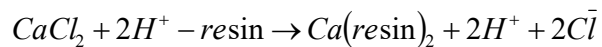
These are big organic molecules having (i) high molecular weight (ii) open and permeable molecular structure. (iii) Acidic ($-\text{COOH}$, $-\text{SO}_3\text{H}$) or basic group ($\text{OH}^-\text{N}^+\text{H}_2$) attached with them.

Organic ion exchangers are of two types :

- i) Cation – exchange resin : If the active ion in ion – exchangers is a cation the resin is called cation – exchange resin, e.g. sulphonated polystyrene resin (H-resin).
- ii) Anion exchange resin: If the active ion in ion-exchange is an anion, it is called anion – exchange resin eg. $-\text{OH}^-$ resin, NH_2 resin.

Removal of cations from hard water :

First of all hard water is passed through a column of cation exchange resin, called zero – card. All the cations present in water, get exchanged with H^+ ions of the resin as shown below :



In hard water (Cation exchange resin)

The above reaction is reversible.

To make it irreversible, water is allowed to flow down the column, Ca^{2+} and Mg^{2+} ion are retained by the resin . the H^+Cl^- & SO_4^{2-} remain in the cation free water obtained down the columns.

LUBRICANT

LUBRICANT:

It is the substance which is used to minimize the friction between two moving or sliding surfaces.

Types of Lubricants-

- c) Solid – (Ex:- Graphite)
- d) Liquid – (Ex:- Oil)
- e) Semi- Solid – (Ex:- Grease)

Purpose of Lubrication-

- i. It reduces the friction and minimizes the wear & tear and prevent metal losing its hardness.
- ii. It minimizes loss of energy.
- iii. It reduces the expansion of metals.
- iv. It acts as a seal & minimizes the leakage of gases.
- v. It acts as a coolant by removing the heat of friction.

Uses of Graphite:

It is used–

- a) in making lead of pencil.
- b) as a lubricant in heavy machinery.
- c) in making electrodes for electrotyping.
- d) as a pigment in paints and stone polish.
- e) as nuclear reactors to slow down the high energy neutron.

Uses of Oil:

It is used as –

- i. Antifoaming agent like glycerol and glycols.
- ii. Corrosion preventer like the compounds of phosphorus on antimony.
- iii. Oiliness improver like vegetable oil.
- iv. Antioxidants like phenolic or amino compounds.
- v. Emulsifiers like sodium salt of sulfonic acid.

Uses of Grease:

- a) It is used for machinery that runs intermittently or is in storage for an extended period of time.

- b) It is used for machinery operating under extreme conditions such as high temperature & pressure, shock load or slow speed under heavy load.
- c) It is generally used for worn components.
- d) Used in trucks, wheel hubs, electric breaker, railway wheel boxes and agricultural machinery.

Fuel

Fuel may be defined as any substance which on combustion release a large amount of heat energy without producing excess residue or by product.

Classification of fuel

The fuel is classified into two types :

- a) Natural fuel
 - i) Solid fuel- Ex- Wood, coal, dung
 - ii) Liquid fuel- Ex- Crude oil petroleum
 - iii) Gaseous fuel- Ex- Natural gas
- b) **Derived fuel**: It is available in following form
 - i) Solid fuel-Coke, Charcoal, Petroleum coke.
 - ii) Liquid Fuel- Ex: kerosene, diesel, Petrol, LPG etc.
 - iii) Gaseous: Coal gas, Water gas Oil gas, Biogas etc.

Characteristic of good fuel

Good fuel possesses the following characteristics :-

- i) It should have high calorific value.
- ii) The ignition temperature should be moderate
- iii) It should contain minimum quantity of moisture.
- iv) It should have controllable combustion rate
- v) It should have small amount of residue
- vi) It should be cheap and easy to transport.

Calorific value of fuel

The amount of heat energy released by the complete combustion of one gram of the fuel or food.

Solid Fuel:-(composition and uses)

1> **Wood:-**

Wood is a very common solid fuel.

Composition:

- a) C=50% b) O=35% c) N=7% d) H=6% e) Ash=2%

Use:-i) It is used as domestic fuel

ii) Used in industries.

Calorific value = 3500 --- 4500 kcal/kg

2) Coal:--

Coal is formed on the materials of vegetable origin under the solid during millions of years under the influence of high temperature and pressure.

Coal is of different types.

a) Peat coal

b) Lignite Coal:-

It is called brown coal.

Composition:-

C=67%, H=5.2%, O= 27.8%

Calorific value= 5500 --- 7000 Kcal/ Kg.

Use:- It is used as fuel in power and producer gas generating plants.

c) Bituminous Coal:-

It has higher carbon content and possesses good heating qualities.

Composition:-

C=90%, H=5%, O=5%

Calorific value = 8000 --- 8500 Kcal/Kg

Use:- It is used in industries in making metallurgical coke, coal gas and Steam for raising temperature

d) Anthracite Coal:-----

It is very hard and possesses low volatile matter.

Composition :-

C=94%, H= 3.5%, O= 2.5%

Calorific value :- 8600 to 8700 Kcal/Kg

Use :- It is used for power generation in metallurgical operations.

Liquid fuel:--

1) Gasoline or Petrol

It is obtained between 40 -- 120°C and is a mixture of hydrocarbon(C_5H_{12} to C_8H_{18})

Average Composition

C=84%, H= 15% , N+S+O=1%

Calorific Value = 11,250 Kcal/Kg

Use:- It is used as fuel in automobiles and aero planes.

2)Kerosene oil:-

It is a fraction obtained between 180 --- 250⁰ and is a mixture of hydrocarbons.(C₁₀ H₂₂ to C₁₆ H₃₄)

Average Composition:-

C=84% , H=16% , S ≤ 1%

Calorific value = 11,100 Kcal/Kg

Use:-i) Used as domestic fuel

ii) Used for making oil gas

3)Diesel Oil:-

It is a fraction obtained between 250 --- 320 and is a mixture of hydrocarbons i.e C₁₅H₃₂ to C₁₈H₃₈

Calorific Value:-- 11,000Kcal/Kg

Use:- It is used as a diesel engine fuel.

1.L.S.H.S.(Low Sulfur Heavy Stock)

Diesel is a fraction obtained between 250-320^{0c} but the thermal cracking of Decane gives some olefins,hydrogen and little sulfur.

- A) Liquid phase thermal cracking- When the heavy oil or gas oil stock is cracked at the temperature range 475-530^{0c}, it contains petrol due to polymerization of small fraction like pentene.
- B) **Furnace oils:** High molecular weight petroleum fractions are called "fuel oils". This fuel is also used for domestic heating.
- C) Light Diesel Oil(LDO) and High Speed diesel(HSD) :Light diesel oil and High speed diesel oil are

Produced from crude oil fractions.The boiling point range is 150-400^{0c} and the hydrocarbons range is C₁₂ to C₁₈.

LDO- is specially used in stationary and marine engines installed in ships and the diesel engines

Used for electricity generation.

HSD is used in diesel engines for automotive purposes in buses, lorries etc.

Producer Gas:

Producer gas is a mixture of combustible gases, CO and H₂ associated with large percentage of non-combustible gas, N₂, CO₂ etc .

Composition:--

$\text{CO} = 22.3\%$, $\text{H}_2 = 8.12\%$, $\text{N}_2 = 52\text{---}55\%$, $\text{CO}_2 = 3\%$

Calorific Value :-- 1300Kcal/m^3

Use :--i) It is used for heating open-hearth furnace.

ii) As a reducing agent in metallurgical operation.

Water Gas:

Water gas is a mixture of combustible gases CO and H_2 with a little non-combustible gases CO_2 and N_2 .

Composition:--- It is used as

i) a source of hydrogen gas

ii) a fuel gas

iii) used for welding purposes.

Liquified petroleum Gas(LPG)

Petroleum gas is a mixture of four hydrocarbon butane, propane, ethane and methane. The main constituent of petroleum gas is however, butane.

Petroleum gas can be easily liquefied under pressure and is called liquefied petroleum gas.

LPG is highly inflammable. It is colourless and odourless. A strong smelling substance called ethyl mercaptan ($\text{C}_2\text{H}_5\text{SH}$) is added to LPG cylinder to help in the detection of gas leakage.

Compressed Natural Gas(CNG)

Natural gas is a mixture of gases and contains mainly methane (CH_4) with small quantities of ethane, propane and butane.

Use:---

i) It is used as a domestic and industrial fuel.

ii) Used as a source of Carbon used in tyre industry.

iii) It is used for the production of hydrogen gas needed in the fertilizer industry.

Polymers

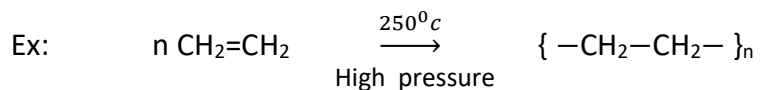
Monomer :

It is a single molecule which can be polymerized to produce polymer.

Ex : i) Ethene ii) Vinyl chloride

Polymer:

The high molecular weight compound formed by joining a no. of simple molecules or monomers through covalent bonds in regular fashion are called polymers.

**Homopolymer :**

A homopolymer is one which is formed by the combination of 'n' molecules of the same substance through covalent bonds in a regular fashion.

Ex $-\text{F}_2\text{C} = \text{CF}_2$, PVC

Co-Polymer :

A polymer which is formed from two different monomers is known as co-polymer.

Ex –i) Nylon-6,6 is a copolymer of two monomers such as hexamethylenediamine and adipic acid.

ii) Buna-S rubber is a copolymer of two monomers i.e butadiene and styrene

Degree of Polymerisation :

Number of monomer molecules that combine to form polymer is called degree of polymerization.

Thermoplastic Polymers :	Thermosetting polymers
i)These are formed by addition polymerization	i)These are formed by condensation polymerization
ii)It is a linear polymer.	ii)It is a cross linked polymer.
iii)These are less brittle and soluble in	iii)These are more brittle and insoluble in

some organic solvents. Ex-Polythene,PVC	organic solvents. Ex-Bakelite
--	----------------------------------

Polythene :

It is formed by the polymerization of ethene. Monomer is ethene.

polythene is of two types :

- i) Low density polythene (ii) High density polythene

uses :

low density polythene is used as :-

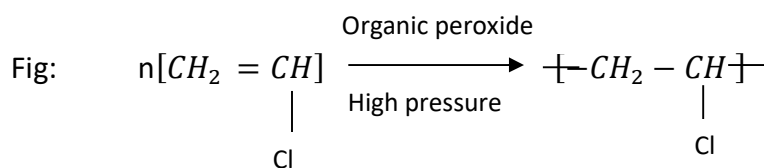
- i) As a packing material
- ii) For insulating wires and cable.
- iii) In the manufacture of pipes, toys, bottles`

High density polythene is used : -

In the manufacture of containers (buckets, tubes etc)and for making house wares, pipes, bottles, tags etc.

Poly-Vinyl Chloride (PVC):

Vinyl chloride polymerizes to polyvinyl chloride in presence of organic peroxide.



Uses :

- i) It is used for making combs, toys, hot drinking cups.
- ii) Used for making tiles to be used in covering ceiling as well as floor.
- iii) Used in the manufacture of lining material for refrigerators & TV channels.

Condensation Polymers:

Bakelite :

It is formed by condensation polymerization of phenol and formaldehyde. The reaction involves the formation of methylene ($-\text{CH}_2-$) bridges at ortho, para or both ortho and para positions. As a result either linear or cross linked material is obtained.

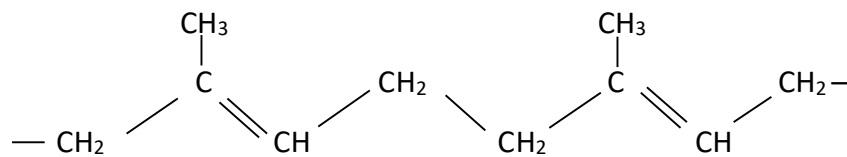
Uses : It is used -

- i) For making electrical insulation parts like switches, plugs, heated handles etc.
- ii) For moulded articles like telephone radio and television cabinets.
- iii) In paints and varnishes
- iv) As a binder for grinding wheels.
- v) For the preparation of decorative articles like plates, dishes, glasses etc.

Natural Rubber :

Natural rubber is a polymer of isoprene (2-Methyl buta-1, 3-diene). It is poly-isoprene with formula $(\text{C}_5\text{H}_8)_n$.

Fig:



Uses : It is used in the preparation of adhesives, submarine cables etc.

Vulcanization of Rubber :

It is the process of heating raw rubber with varying amounts of sulfur (3.5%) to 140°C for some time.

when sulfur reacts with polymer molecules forming a cross linked network. Hardness of rubber increases as added sulphur combines chemically at the double bonds of different rubber chains.

Uses :

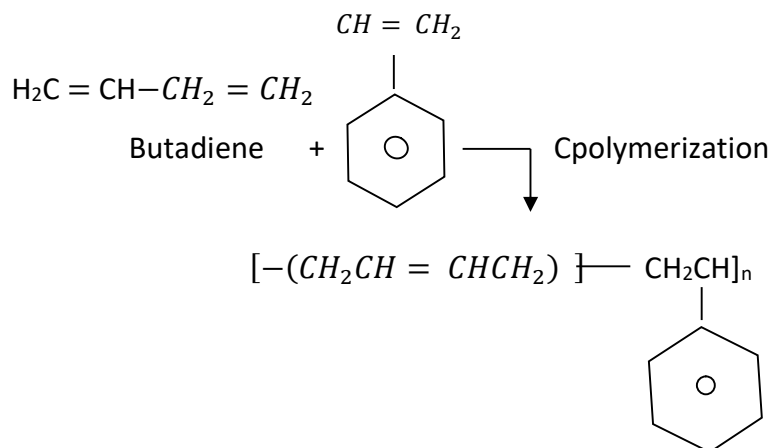
- i) It has high resistance to oxidation.

- ii) It has high chemical resistance to organic solvents.
- iii) It has much better electrical insulation power.

Synthetic Rubbers : The artificial rubber which can be stretched to at least twice its length and on releasing the stress, it returns to its original shapes and size. Ex –

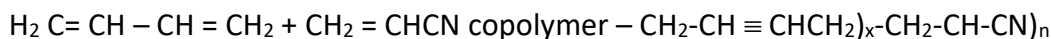
- i) Buna – S : It is obtained by co-polymerization of butadiene and styrene.

Fig:



Uses :

- (i) For manufacturing of tyres, soles and other components of shoes.
 - (ii) For insulating wires and cables as adhesives and lining for vessels.
2. Buna – N : It is a copolymer of butadiene and acrylonitrile.



Uses :

- i) Used as insulator
- ii) Used to manufacture parts for automobiles aircraft
- iii) Used for making conveyer belts, adhesives and oil resistant forms, water proof shoes, rubber soles, tyre and tube.

Adhesives :

These are the substances capable of binding materials together by surface attachment, thus providing structural and geometrical continuity.

Uses :

Mainly used in wood work industry as a binding agent like gum, paste, glue etc cement is also an adhesive.

Type of Adhesive ;

a) Natural Adhesives b) Synthetic Adhesives

Natural Adhesives :

These are based on naturally occurring materials.

a) Shellac :

- (i) It is used in sealing waxes
- (ii) As a resin binder for mica based insulating materials, in varnishes, polishes and leather dressings.
- (iii) Used for making belts, conveyors etc.

b) Asphalt :

- i) It is used in paints, dielectrics, fungicide and as a water proofing material.
- ii) A mixture of asphalt with gravel is used in roofing materials and in road surfacing.
- iii) Also used for making bonding paper, cloth and metal bonding.

C) Starch : It is used as –

- i) Paper conversion, book binding industries etc.
- ii) Veneer ply-wood.
- iii) Wood bonding, office paste, laminating, paper board, postage stamps etc.

RUBBER BASED ADHESIVE

Used for type of rubber based adhesive contains 40-45% reclaimed rubber, resin, drier and solvent.

- i) Second type contains gum, rubber resin and about 15% solids.
- ii) Another type of such adhesive or cement contains compounded latex.

b) Synthetic Adhesives :

- i) Phenol formaldehyde resins
- ii) Urea formaldehyde resins

i) Phenol – formaldehyde resins :

These are formed by condensation of aldehydes and ketones and used in wood gluing where water resistance is most important.

The polymerization of phenol and formaldehyde results in the formation of Bakelite, which is used in making combs phonograph records, electrical goods, fountain pen barrels.

ii) Urea – formaldehyde resins:

These resins are superior to phenol formaldehyde resins and is a condensation polymer of urea and formaldehyde.

Uses : i) It is a odorless resin and mixed with wood floor and a desired dye before moulding.

ii) for manufacturing of crease resisting textiles, adhesives, plywood, unbreakable cups and laminated sheets.

CHEMICALS IN AGRICULTURE

Pesticides: Pesticides are chemical compounds that are used to kill pests, including insects, rodents, fungi, and unwanted plants (weeds). The term pesticide includes all the following: i. Insecticides ii. Herbicides iii. Fungicides.

Insecticides: Insecticides are substances used to kill insects. Examples: - Chlorinated hydrocarbons like DDT, BHC (gamma-hexachlorocyclopentadiene), Aldrin, Dieldrin etc.

Uses- Insecticides are used in agriculture, medicine, industry and by consumers.

Herbicides: A herbicide is a chemical substance used to kill unwanted plants. These are commonly known as weedkillers. Examples: Acetochlor, Amitrole, Arsenic acid, dinitrophenol, dipyridyl, carbamate, Propanil, Paraquat, etc.

Uses- Herbicides can be used to clear waste ground, industrial and construction sites, railways, and railway embankments as they kill all plant material with which they come into contact. Also, these are applied in ponds and lakes to control algae & plants such as water grasses that can interfere with activities like swimming and fishing.

Fungicides: Fungicides are pesticides that prevent, kill, mitigate, or inhibit the growth of fungi on plants. Ex- Bleaching powder, CuSO₄ solution, aluminium phosphide, Copper oxychloride, Carbendazim, Carboxin, Mancozeb, etc.

Uses- These are used to control fungi that damage plants.

Bio-fertilizers: Biofertilizers are the substance that contains living microorganism. Biofertilizers increase the nutrients of host plants when applied to their seeds, plant surface or soil by colonizing the rhizosphere of the plant. These are environment friendly substitute for harmful chemical fertilizers. The microorganism in Biofertilizers restore the soil's natural nutrient cycle and build soil organic matter. These are extremely advantageous in enriching soil fertility & fulfilling plant nutrient requirements. Ex- Rhizobium, Azotobacter, Azospirillum, Blue green algae etc.

Uses -i. Rhizobium inoculant is used for leguminous crops. ii. Azotobacter can be used with crops like wheat, maize, mustard etc. iii. Blue green algae is used for paddy crops. iv. Azospirillum is used for maize, sugarcane, millets etc.